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(54) Optical transmission system

(57) An optical fibre transmission system has a large number (e.g. 30) of nodes connected to an optical transmission line by passive couplers, there being at each node an incoming coupler and an outgoing coupler. If the adjacent nodes have adjacent frequencies, crosstalk is a problem.

In the present system the allocation of frequencies to nodes is on a non-adjacent basis, preferably to a preset pattern. This reduces crosstalk between the channels formed by the various frequencies.

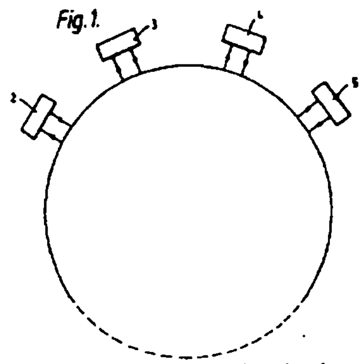
In the system described the transmission line uses mono-mode optical fibre, and the frequency allocation to the nodes is as in the following table

Node	Frequency	Node	Frequency
1	1	5	9
2	3	6	11
3	5	7	13
4	7	8	15

and so on.

When the odd-numbered frequencies have all been allocated, the even-numbered ones 2, 4, 6, 8... are used.

Fig. 1.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

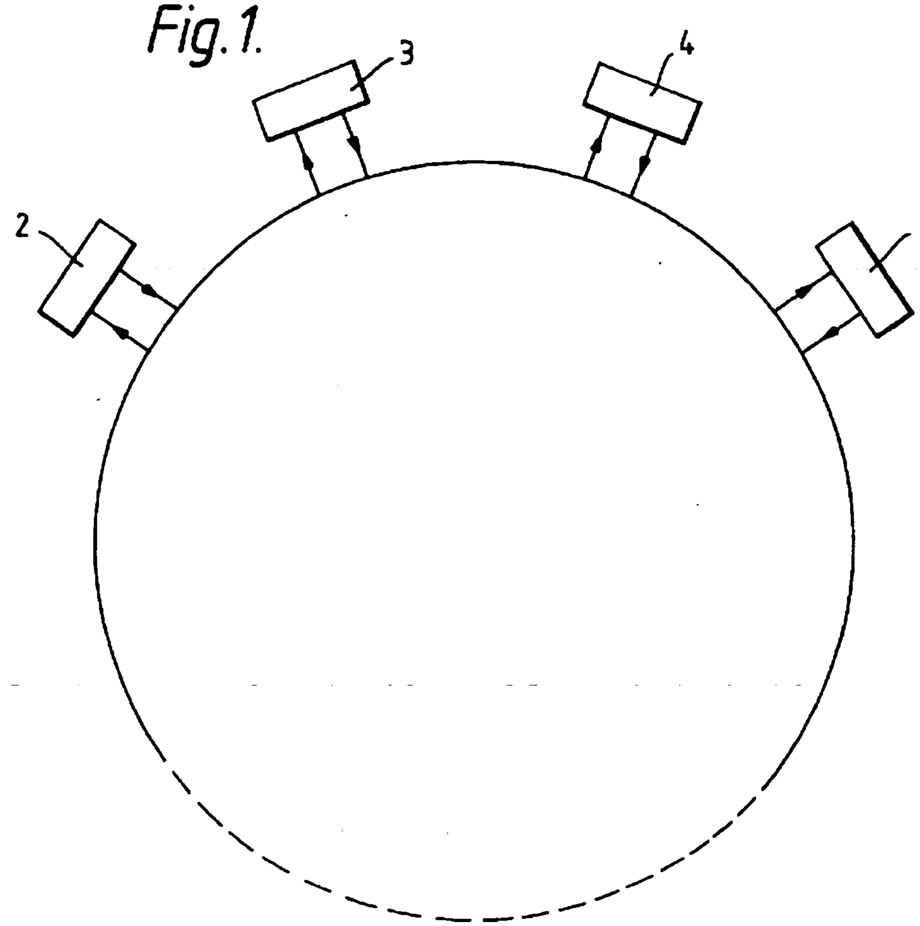

Fig.2.

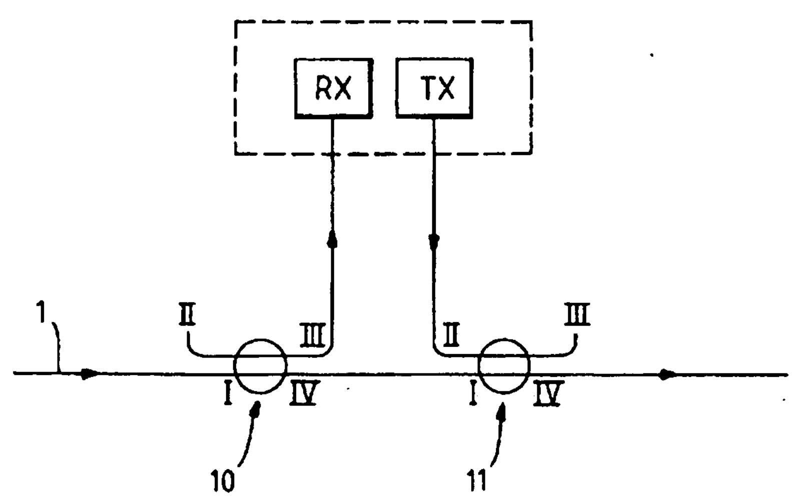

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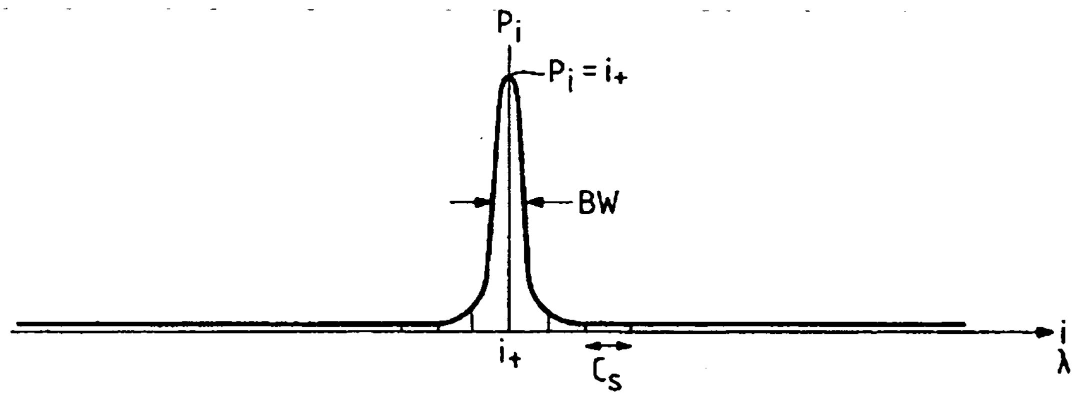
Fig. 3.



SPECIFICATION

Optical Transmission System

The present invention relates to an optical telecommunication system, preferably one in which the optical transmission line is of the optical fibre type. Each of a number of nodes is connected to the transmission line by a passive coupler. Thus at each node the major portion of the light travelling along the line goes past the node while a proportion is tapped off by that node's coupler. Each node also has an outgoing coupler via which the light conveying data from that node is applied to the transmission line. Such a system is shown schematically in Figure 1.

In Figure 1 we see an optical highway 1 to which nodes 2, 3, 4, 5. . . . . . are connected, each node being connected to the highway 1 by incoming and outgoing optical fibres. Although the highway is shown as being of the closed-loop type, it could also be of the linear type.

As can be seen from Figure 2, each node has an optical receiver Rx coupled to the highway 1 by an optical coupler 10, and a transmitter Tx coupled to the highway by another optical coupler 11. Each coupler has four ports, designated I, II, III and IV in Figure 2, and the port-to-port coupler losses are as shown for one example in the following table.

Port-to-Port Coupler Losses (dB)

		INPUT			
		I	II	III	IV
O	I	—	—	−11	−0.36
U	II	—	—	−0.36	−11
T	III	−11	−0.36	—	—
P	IV	−0.36	−11	—	—
U					
T					

The frequencies (and hence wavelengths) available for transmission are distributed amongst the nodes and a node wishing to receive the light from another node adjusts its tunable filter, e.g. a Fabry-Perot etalon, to give maximum transmission at the desired wavelength. This assumes that the frequencies available are allocated to the nodes for transmission therefrom.

Some problems exist in such systems in respect of crosstalk between the channels formed by the various frequencies, and it is an object of the invention to provide a system in which these problems are minimised.

According to the present invention, there is provided a telecommunication system which includes a number of nodes coupled to an optical transmission line by optical couplers, in which data is conveyed over the optical transmission line by modulation on to carriers having different frequencies, and hence different wavelengths, in which each said frequency is allocated to one of said nodes so that a said node uses signals modulated on to a carrier at its said frequency, and in which the pattern of allocation of the frequencies to the nodes is such that adjacent ones of said nodes are allocated non-adjacent ones of said frequencies.

A wavelength division multiplexed (WDM) optical transmission system can be constructed with two two-way passive couplers for each node, one to couple light off the trunk transmission line to the receiver and the other to couple light onto the transmission line from the transmitter. In the arrangement described, each node is allocated a frequency at which it transmits data, but it would also be possible for each node to be allocated a frequency at which it receives. In the latter case it is possible to provide an extra frequency for use for "broadcasting" to all stations. The available wavelengths for transmission are distributed amongst the nodes and a node wishing to receive the light from another node adjusts its tunable filter, such as a Fabry Perot entalon, to give maximum transmission at the desired wavelength.

In such a system, crosstalk can be a problem, and the crosstalk suppression is given by the expression:

$$P_{i=i_r} = \sum_{i=1}^{i=C} \frac{P_i}{1+\left(\frac{2\ FSR^2}{\pi BW}\right)\sin^2\left(\frac{C_e\pi(i-i_r)}{FSR}\right)}$$

where

i is the frequency number of the node

i_r is the received frequency number

C is the number of nodes

P_i is the power arriving from node whose frequency is i

FSR is the Free Spectral Range of the tunable filter used in the node to set it to the frequency to be received by that node.

BW is the full width half maximum value of the filter transmission characteristic

C_s is the channel spacing in wavelength.

Some of these parameters are indicated in Figure 3, which relates to the response at a node.

In the present system, to reduce crosstalk the wavelengths are distributed so that the sum in the above expression is a minimum, i.e. the sum of the $(i-i_j)$ terms is increased. However, the fact that some light is coupled off to each receiver means that there will be some loss in the trunk transmission line and any attenuation will be added to this. For example, 30 nodes separated by 0.27 dB of attenuation, with −11 dB coupled off and on at each receiver and transmitter, show approximately 2.4 dB improvement in crosstalk suppression by assigning every other wavelength to adjacent nodes (the Fabry-Perot filter has a free spectral range of 120 nm and a passband width of 0.1 nm). The improvement in crosstalk suppression increases with increased number of nodes and increased transmission line loss.

As an example, with a system of the local area network (LAN) type, with 30 nodes connected to the same trunk transmission line, the 30 available frequencies are allotted as follows:

Node	Frequency	Node	Frequency
1	1	5	9
2	3	6	11
3	5	7	13
4	7	8	15 and so on.

The frequencies differ from each other by a constant interval, and increase in the order 1, 2, 3, ... When the odd-numbered frequencies are used up, the even-numbered frequencies are used. Thus crosstalk is, as indicated above, reduced to a useful extent as compared with a system in which adjacent nodes have adjacent frequencies allocated to them.

In an optical local area network (LAN) a number of nodes is interconnected by a trunk optical transmission line, with each node having a receiver and a transmitter. At each node there are two two-way passive couplers, one to couple a proportion of the light travelling along the transmission line to the receiver, and the other to couple the output of the transmitter on to the transmission line. In the type of network where each node always transmits on the same frequency, it is not necessary to monitor the fibre for a vacant time slot as is called for in many digital LANs.

As in many LANs, each node can serve more than one user, in which case with one frequency allocated to each node only one of those users has access to the system at any one time.

In the arrangement described herein, the optical transmission line uses mono-mode optical fibre, but other forms of optical transmission line can be used.

CLAIMS

1. A telecommunication system which includes a number of nodes coupled to an optical transmission line by optical couplers, in which data is conveyed over the optical transmission line by modulation on to carriers having different frequencies, and hence different wavelengths, in which each said frequency is allocated to one of said nodes so that a said node uses signals modulated on to a carrier at its said frequency, and in which the pattern of allocation of the frequencies to the nodes is such that adjacent ones of said nodes are allocated non-adjacent ones of said frequencies.

2. A system as claimed in claim 1, in which the frequency differences between the carriers allocated to any one pair of adjacent nodes is a multiple of the minimum frequency difference between carriers.

3. A system as claimed in claim 1 or 2, in which each said carrier frequency is allocated to one of said nodes for the transmission of data therefrom.

4. A system as claimed in claim 1 or 2, in which each said carrier frequency is allocated to one of said nodes for the reception of data thereby.

5. A system as claimed in claim 1, 2, 3 or 4, in which the frequencies are allocated to the nodes in the manner set out in the following table:

Node	Frequency	Node	Frequency
1	1	5	9
2	3	6	11
3	5	7	13
4	7	8	15 and so on,

followed by the allocation of the even-numbered frequencies 2, 4, 6 . . . .

6. A system as claimed in any one of the preceding claims, and in which the optical transmission line is mono-mode optical fibre.

7. A telecommunication system of the local area network type, substantially as described herein.

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